Research and Development for Liquid Argon Time Projection Chamber

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Overview

- Background
  - LAPD Phase I
  - LAPD Phase II
  - Cosmic Rays
  - Scintillation Counters
- Efficiency Testing
- Operating Voltage
- Scintillator Holders
- Model TPC
- RTDs
- Future projects

LAPD Phase I

- Main goal of was to determine whether required electron drift times can be achieved without prior evacuation of a large vessel
- Instead of vacuum, pushed air out with gaseous argon
- Then liquid filled and filtered in two ways:
  - Molecular sieve to remove water
  - Trigon filter to remove oxygen
- Polar molecules and any non-noble elements are contaminants that could interact with the drifting electrons
- Purity Monitors

LAPD Phase II

- Use scintillator counters as a trigger for “Long-Bo”
- Time projection chamber tracking cosmic ray muons via ionized Argon
- 3 planes of wires

Cosmic Rays

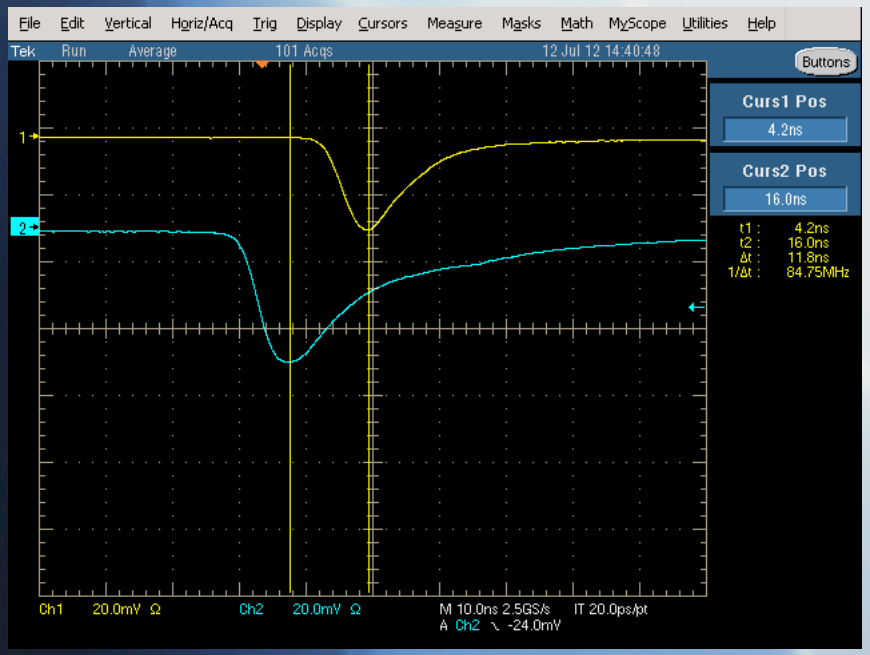
- Protons, alpha particles, heavy nuclei
- Interact in the upper atmosphere
- Emit mostly pions
- Pions decay into muons
- Muons detected at the surface
- Cycles with the solar cycles

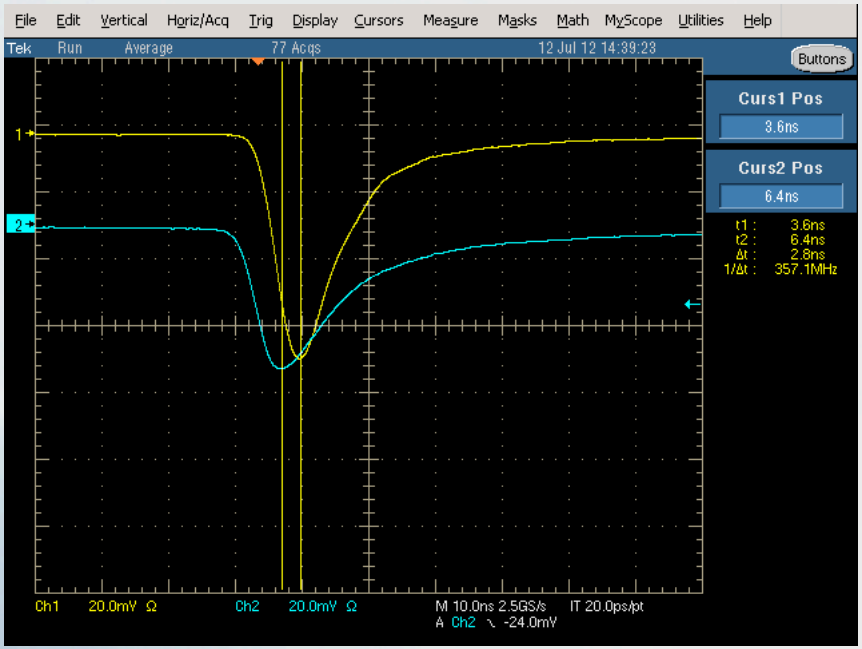
Scintillation Counters

- Total internal reflection
- Stokes shift
- Photomultiplier tube

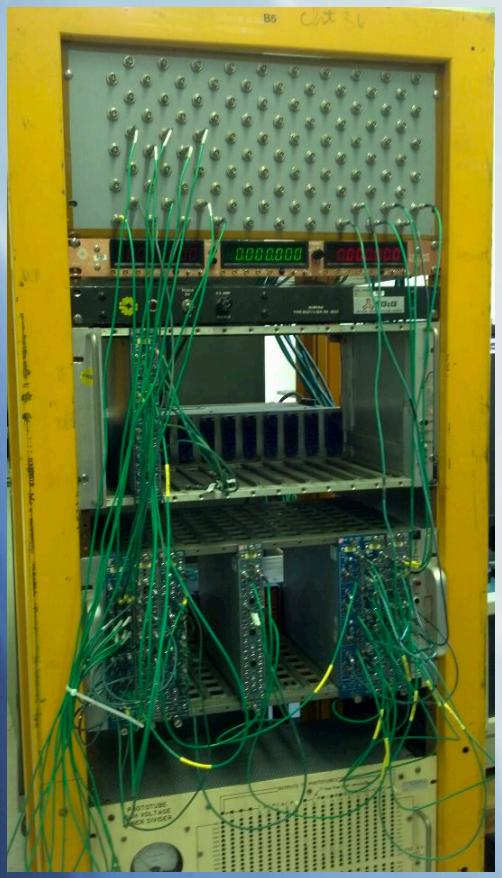
Initial Tests

- Light Leaks
- Travel time





Electronic Systems



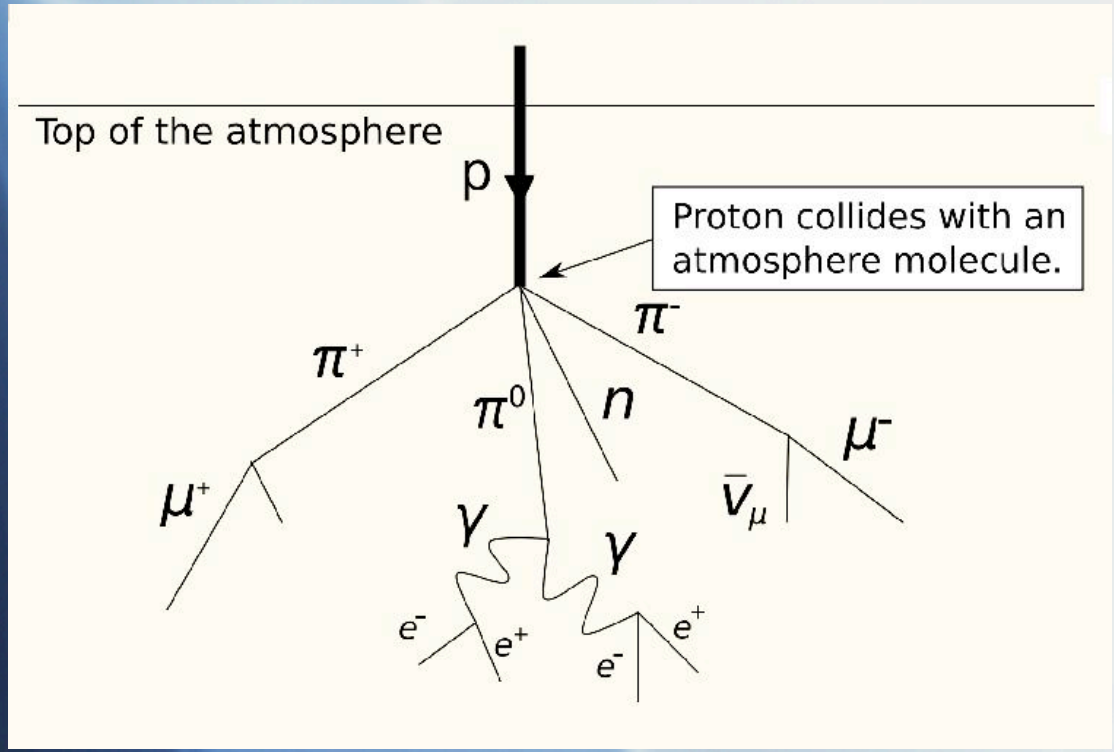
- NIM electronics with LEMO connectors
- Amplifier, Discriminator, Coincidence, Scalar
- Voltage range from 1320 to 1900 V, constrained to 1700

Efficiency

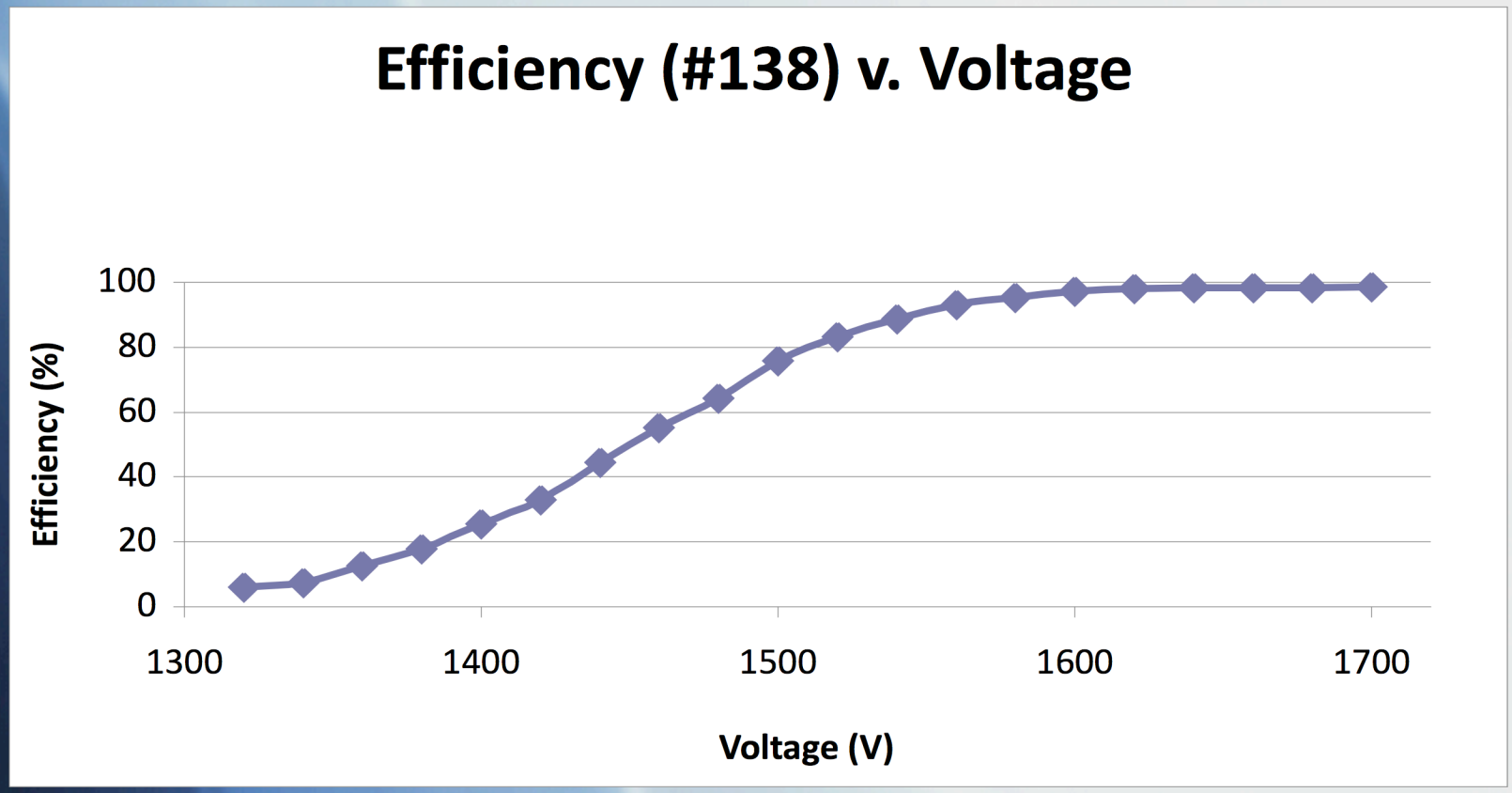
Distance	Efficiency	Counter	Uncertainty	Counter Position
2	0.82	21	0.0023	Vertical
1	0.96	21	0.00053	Horizontal
1	0.93	21	0.0057	Vertical
0.5	0.98	21	0.0037	Vertical
0.5	0.99	21	0.00091	Horizontal

Cosmic Ray Showers

- When one cosmic ray produces lots of muons that can be scattered over wide distances.



Operating Voltage



Counter #	Recommended Voltage (V)	Max Efficiency (%)
98	1600-1680	91.9
138	1640-1700	98.6
18-44	1500-1700	98.6
132	1580-1700	98.6
145	1660-1700	98.5
6	1580-1700	98.2
131	1600-1700	98.2
101	1500-1700	98.3
16	1560-1680	96.8
21	1560-1680	97.3
2	1520-1680	97.7
11	1520-1680	97.8
95	1700+	91.2
19-77	1680-1700	96.2
115	1720+	91.2
80	1480-1680	97.1
4	1480-1680	97.8
47	1400-1700	97.6

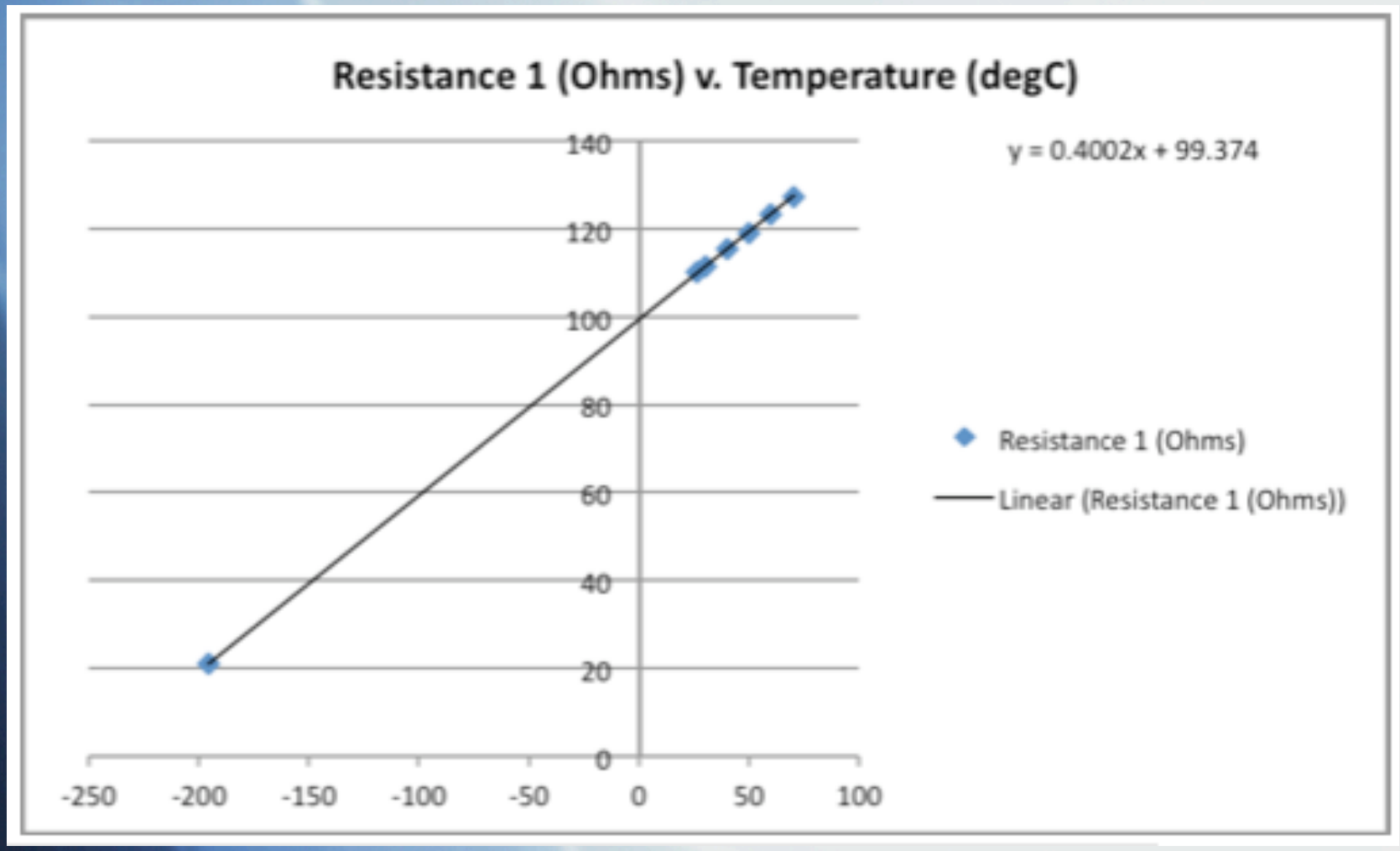
Scintillator Holders

- Designed and fabricated brackets to hold the scintillators near the tank
- Scintillators hang from ladders in two different orientations
- Determined the six locations of the ladders around the LAPD

RTD

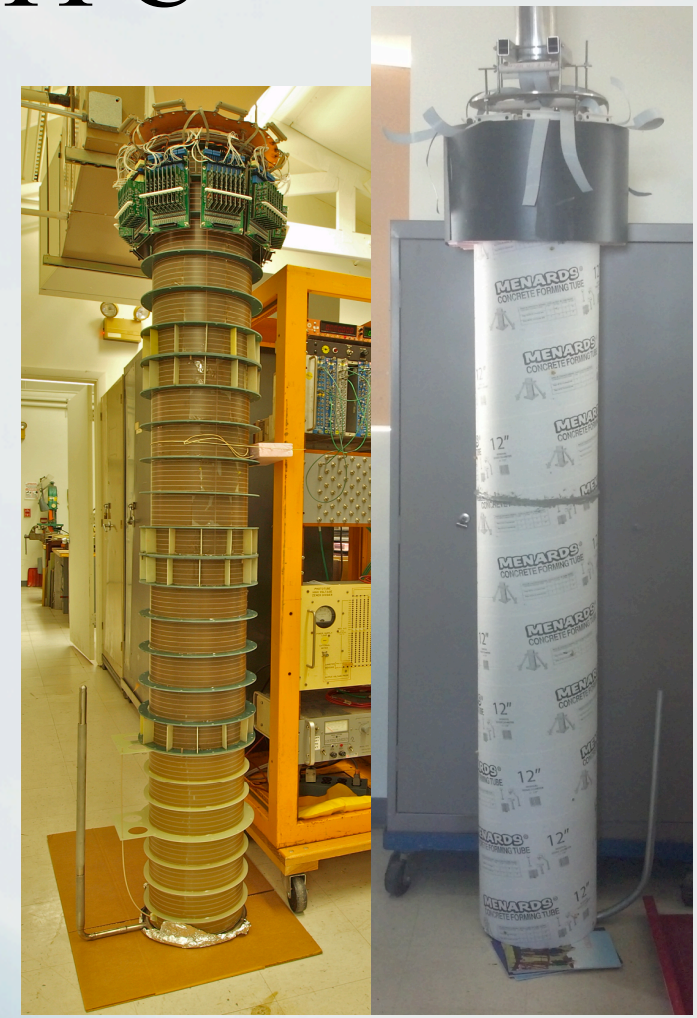
- Resistive Temperature Devices
  - Change resistance based on the temperature
  - Will be used to determine temperature gradient in the LAPD

Temp (degC)	Resistance 1 (Ohms)	Resistance 2 (Ohms)	Resistance 3 (Ohms)	Average	σ
26	110.1704	110.2731	110.1267	110.1901	0.075155
30	111.3453	111.4638	111.3263	111.3785	0.074509
40	115.4732	115.6045	115.5326	115.5368	0.065749
50	119.1027	119.223	119.0943	119.14	0.072003
60	123.3417	123.4838	123.3945	123.4067	0.071827
70	127.3224	127.4727	127.3968	127.3973	0.075151
-196	20.88	20.73	20.73	20.78	0.086603


Resistance 1 (Ohms) v. Temperature (degC)
y = 0.4002x + 99.374
140
120
100
80
60
40
20
0
-250
-200
-150
-100
-50
0
50
100
Resistance 1 (Ohms)
Linear (Resistance 1 (Ohms))

Model TPC

- TPC is 2 meters tall and contains sensitive electronics
- Ceiling closer than 2 meters to the top of the LAPD
- Need to model insertion before doing it with the real one
- Created a 1:1 model of the TPC with which to model insertion



Future Testing

- 35-Ton cryostat
- LBNE
- Future of neutrino studies and the intensity frontier

Acknowledgements

- Stephen Pordes, Mentor
- Hans Jostlein
- Michelle Stancari
- Tingjun Yang
- Matt Hall
- Cindy Fuhrer